Amendments to the Drawings:

The attached sheet of drawings includes changes to Figure 1A. This sheet, which includes Figures 1A and 1B, replaces the original sheet including Figures 1A and 1B.

Attachment: Replacement Sheet

REMARKS/ARGUMENTS

Claims 1, 3-7 and 9-23 are currently pending in the present application, of which claims 1 and 23 are independent claims. Claim 10 has been withdrawn from consideration. Claim 2 has been previously canceled. Claim 8 has been canceled without prejudice or disclaimer by this Amendment. Claim 1 has been amended by this Amendment. New claim 23 has been added by this Amendment.

Drawings

The drawings stand objected to because the Examiner asserts that Fig. 1A seems to indicate that element 9 includes 9a, 10 and 9b, but element 9, in fact, only includes 9a and 9b. The Examiner suggests changing Fig. 1A similar to Fig. 2A showing that element 9 includes only 9a and 9b.

Applicants submit herewith a replacement sheet that shows element 9 includes only 9a and 9b in Fig. 1A.

Withdrawal of the objection to the drawings is therefore requested.

Claim Objections

Claims 1, 3-9 and 11-22 stand objected to because of informalities.

The Examiner asserts that claim 1 recites "wherein at least one layer... is embedded in the current expansion layer", which is not consistent with the figures. The Examiner recommends replacing the term "embedded" with the term "sandwiched".

Independent claim 1 has been amended as suggested by the Examiner.

Withdrawal of the objection to the claims is therefore requested.

Claim Rejections under 35 USC § 112

Claims 1, 3-9 and 11-22 stand rejected under 35 USC § 112, second paragraph as indefinite. The Examiner asserts that claim 1 recites the limitation "a two-dimensional electron and hole gas" in the last line of the claim, but that it is unclear whether this limitation is the same as the limitation "a two-dimensional electron gas or hole" recited in the 9th line of the claim.

Independent claim 1 has been amended to clarify this limitation.

Withdrawal of the rejection under 35 USC § 112, second paragraph is therefore requested.

Claim Rejections under 35 USC § 102 and 35 USC § 103

Claims 1, 3, 4, 6, 8, 11, 15, and 22 stand rejected under 35 USC § 102(b) as anticipated by U.S. Pub. No. 2004/0004223 ("Nagahama"). Claims 5, 7, 9, 12-14 and 16 stand rejected under 35 USC § 103(a) as unpatentable over Nagahama. Claims 17-20 stand rejected under 35 USC § 103(a) as unpatentable over Nagahama in view of U.S. Pat. No. 5,744,828 ("Nozaki"). Claim 21 stands rejected under 35 USC § 103(a) as unpatentable over Nagahama in view of U.S. Pub. No. 2003/0111667 ("Schubert").

Discussion of Disclosed Embodiments

The following descriptive details are based on the specification. They are provided only for the convenience of the Examiner as part of the discussion presented herein, and are not intended to argue limitations which are unclaimed.

Applicants' disclosed embodiments are directed to a thin-film LED. (See FIG. 1A of the published application showing a cross section of the line I-II from a plan view shown in FIG. 1B). The thin-film LED contains an epitaxial layer sequence 16 comprising an active layer 7.

The active layer 7 emits electromagnetic radiation 19 in a main radiation direction 15. The electromagnetic radiation 19 emitted in the main radiation direction 15 by the active layer 7 is coupled out from the thin-film LED through a main area 14. (See paragraph 46 of the published application).

A first contact layer 11, 12, 13 is provided on the main area 14 of the thin-film LED. A current expansion layer 9 containing a first nitride compound semiconductor material, preferably GaN, is contained between the active layer 7 and the first contact layer 11, 12, 13. Embedded in the current expansion layer 9 made of the first nitride compound semiconductor material is at least one layer 10 made of a second nitride compound semiconductor material, preferably made of AlGaN. In other words, the current expansion layer 9 is a multilayer layer comprising for example two GaN partial layers 9a, 9b separated from one another by an embedded AlGaN layer 10. (See paragraph 48 of the published application). The transverse conductivity of the current expansion layer 9 is improved by the semiconductor layer 10 sandwiched in the current expansion layer 9. (See paragraph 49 of the published application).

FIG. 4 schematically illustrates the profile of the dopant concentration Δ as a function of a spatial coordinate z, which runs perpendicular to the current expansion layer, that is to say parallel to the main radiating direction. An AlGaN layer is embedded in a current expansion layer made of GaN, both the GaN layer and the AlGaN layer being n-doped in each case. The AlGaN layer has a higher dopant concentration in the regions 24 adjoining the GaN layer than in its inner portion (so-called doping spikes). The number of free electrons which have a high mobility in the potential wells 25 illustrated in FIG. 3B is therefore increased further and the transverse conductivity is consequently improved further. (See paragraph 63 of the published version of the present application).

Arguments

The art cited by the Examiner fails to teach or suggest "the at least one layer made of the second nitride compound semiconductor material has a doping, a dopant concentration being higher in regions adjoining the current expansion layer than in a central region of the at least one layer made of the second nitride compound semiconductor material", as expressly recited by Applicants' amended claim 1 because Nagahama discloses that the dopant concentration is the same in both layers of the cladding layer 5. Moreover, there is no hint or suggestion in Nagahama of a diffusion of atoms across interfaces in Nagahama's superlattice.

The Examiner (at page 6 of the Office Action) asserts that Nagahama discloses in Fig. 1 and paragraphs 72-74 a p-type cladding layer 5 comprised of a super lattice that comprises first and second layers having different constitutions, which read on the claimed current expansion layer and the at least one layer made of the second nitride compound semiconductor material. Applicants disagree.

Nagahama discloses in paragraph 73 that the second layer of the p-type cladding layer 5 is composed of p-type $Al_YGa_{1-y}N$ doped with the same amount of Mg as in the first layer. However, Nagahama fails to disclose, teach or suggest that the doping concentration in the second layer is higher in regions adjoining the first layer than in a central region of the second layer.

The Examiner also asserts that paragraph 165 of Nagahama suggests a GaN layer with a higher dopant concentration than an AlGaN layer adjacent to the GaN layer, wherein the center region of the AlGaN layer has a lower dopant concentration than the edge of the AlGaN layer because some dopants can diffuse from the higher doping GaN layer to the lower doping GaN layer at the edge of the AlGaN layer. Applicants respectfully disagree.

Paragraph 165 of Nagahama describes a case where the AlGaN layer and the GaN layer are doped with the same amount of Mg. Nagahama explains that the same amount of dopant concentration (1×10^{20} cm^{-3}) in both the AlGaN and the GaN l layers leads to different carrier concentrations (1×10^{18} cm^{-3} in GaN and 1×10^{20} cm^{-3} in AlGaN) because of different activation ratios. Thus, although the carrier concentrations are different in the two layers, the dopant concentration is the same. Accordingly, even if a diffusion of the dopants at the interface occurred, there would be no increase of the dopant concentration in the edge regions of the AlGaN layer.

Furthermore, Nagahama fails to disclose, teach or suggest any local variation of the dopant concentration in the layer with the higher band gap. That is, Nagahama fails to teach or suggest that the doping concentration in the second layer is higher in regions adjoining the first layer than in a central region of the second layer. The Examiner assumes that a variation of the dopant concentration might be caused by a diffusion process of dopants from the GaN layer to the AlGaN layer. However, there is no indication of such a diffusion process at work in Nagahama, and Nagahama merely mentions the movement of charge carriers, i.e., the movement of electrons or holes, in the superlattice. The dopants are atoms in the crystal lattice of the semiconductor materials; there is no hint or suggestion in Nagahama of a diffusion of atoms across the interfaces in the superlattice.

Nagahama therefore fails to disclose, teach or suggest "the at least one layer made of the second nitride compound semiconductor material has a doping, a dopant concentration being higher in regions adjoining the current expansion layer than in a central region of the at least one layer made of the second nitride compound semiconductor material", as expressly recited by Applicants' amended claim 1.

Accordingly, amended claim 1 is deemed to be patentable over Nagahama.

The other cited references, Nozaki and Schubert, were cited by the Examiner as purportedly disclosing the features of various dependent claims. However, nothing has been found in Nozaki and Schubert that would remedy the deficiencies of Nagahama with respect to the features of claim 1 discussed above.

Claims 3-7 and 9-22, which each depend from independent claim 1, distinguish the invention over the applied prior art for reasons discussed above in regard to the independent claims, as well as on their own merits.

New Independent Claim 23

New independent claim 23 contains the features of amended claim 1 and the additional limitation "wherein the dopant concentration in the regions adjoining the current expansion layer is higher than in a dopant concentration in the current expansion layer." Support for new independent claim 23 is found at least in original claims 1 and 8 and Fig. 4, which shows the dopant profile. In particular, Fig. 4 shows the doping concentration in the regions 24 of the AlGaN layer which adjoin the current expansion layer is both higher than in the central region of the AlGaN layer and higher than in the GaN current expansion layer.

New independent claim 23 is therefore patentable for at least the same reasons discussed above with respect to independent claim 1. Furthermore, the additional limitation "wherein the dopant concentration in the regions adjoining the current expansion layer is higher than in a dopant concentration in the current expansion layer" makes clear that the higher doping of the edge regions of the at least one layer made of the second nitride semiconductor material cannot be caused by a diffusion of dopants from the adjacent current layer (as assumed by the Examiner in the rejection of claim 8 in the Office Action). Moreover, Nagahama fails to provide any reason for the skilled

artisan to dope the edge regions of the layer of the second nitride layer material of Nagahama in a targeted manner. In contrast, paragraph 24 of the published version of the present application explains that the edge regions of the layer of the second nitride layer material of Nagahama are doped in a targeted manner in order to obtain an increased number of free charge carriers in the regions in which the transverse conductivity is increased by the formation of a two-dimensional electron or hole gas.

Accordingly, new claim 23 is deemed to be patentable over Nagahama.

The other cited references, Nozaki and Schubert, were cited by the Examiner as purportedly disclosing the features of various dependent claims. However, nothing has been found in Nozaki and Schubert that would remedy the deficiencies of Nagahama with respect to the features of claim 23 discussed above.

CONCLUSION

In view of the foregoing, reconsideration and withdrawal of all rejections, and allowance of all pending claims is respectfully solicited.

It is believed that no fees or charges are required at this time in connection with the present application. However, if any fees or charges are required at this time, they may be charged to our Patent and Trademark Office Deposit Account No. 03-2412.

Respectfully submitted,
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